US009438607B2

# (12) United States Patent

Yasuie et al.

(10) Patent No.: US 9,438,607 B2

(45) Date of Patent: Sep. 6, 2016

(54) **INFORMATION PROCESSING APPARATUS AND VERIFICATION CONTROL METHOD**

(71) Applicant: **FUJITSU LIMITED**, Kawasaki-shi, Kanagawa (JP)

(72) Inventors: **Takeshi Yasuie**, Kawasaki (JP); **Taichi Sugiyama**, Kawasaki (JP)

(73) Assignee: **FUJITSU LIMITED**, Kawasaki (JP)

( * ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 256 days.

(21) Appl. No.: **14/221,454**

(22) Filed: **Mar. 21, 2014**

(65) **Prior Publication Data**

US 2014/0297767 A1 Oct. 2, 2014

(30) **Foreign Application Priority Data**

Mar. 28, 2013 (JP) ................................ 2013-067791

(51) **Int. Cl.**
***H04L 29/06*** (2006.01)

(52) **U.S. Cl.**
CPC ............. ***H04L 63/12*** (2013.01); ***H04L 63/123*** (2013.01)

(58) **Field of Classification Search**
CPC ............................ H04L 63/123; H04L 63/12
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

| | | | | |
|---|---|---|---|---|
| 8,914,675 | B2 * | 12/2014 | Hatano | G06F 11/263 714/32 |
| 9,015,830 | B2 * | 4/2015 | Yasuie | G06F 21/44 726/22 |
| 2011/0228684 | A1 * | 9/2011 | Sugiyama | H04L 43/0811 370/252 |
| 2013/0246359 | A1 * | 9/2013 | Sugiyama | G06F 17/30371 707/639 |

FOREIGN PATENT DOCUMENTS

| | | | | |
|---|---|---|---|---|
| JP | 2009-301252 | A | | 12/2009 |
| JP | 2009301252 | A | * | 12/2009 |
| JP | 2010-113380 | A | | 5/2010 |
| JP | 2010113380 | A | * | 5/2010 |
| JP | 2010-205011 | A | | 9/2010 |
| JP | 2010205011 | A | * | 9/2010 |
| JP | 2011-199680 | A | | 10/2011 |

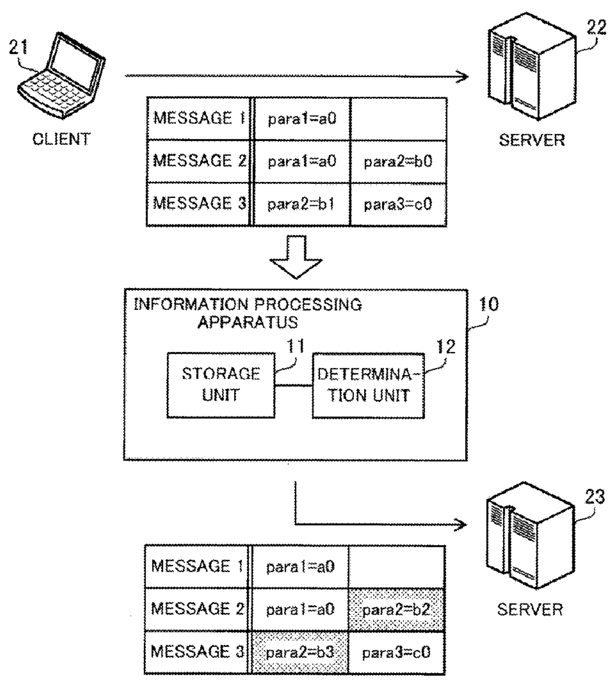
* cited by examiner

*Primary Examiner* — Michael C Lai
(74) *Attorney, Agent, or Firm* — Fujitsu Patent Center

(57) **ABSTRACT**

An information processing apparatus obtains a plurality of messages transmitted between a client and a server, each message including at least one of a plurality of parameters and a value of the parameter. The information processing apparatus detects a parameter having different values set in different messages among the obtained plurality of messages, from among the plurality of parameters. According to the detection result, the information processing apparatus determines a rewrite parameter whose value is rewritten when using the plurality of messages for verification of a server, among the plurality of parameters.

**8 Claims, 15 Drawing Sheets**



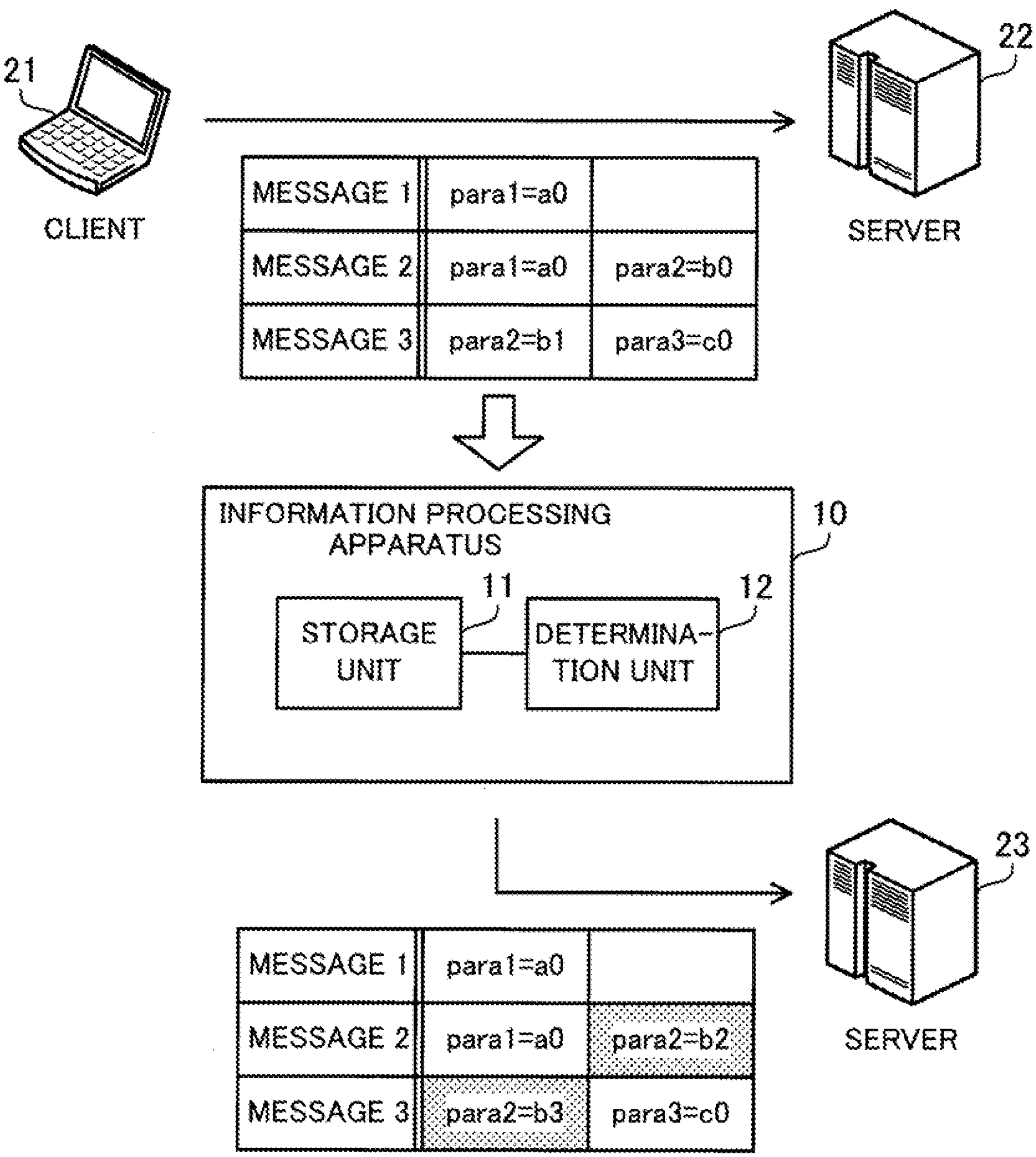

21
CLIENT
22
SERVER
MESSAGE 1
para1=a0
MESSAGE 2
para1=a0
para2=b0
MESSAGE 3
para2=b1
para3=c0
INFORMATION PROCESSING APPARATUS
10
11
STORAGE UNIT
12
DETERMINATION UNIT
23
SERVER
MESSAGE 1
para1=a0
MESSAGE 2
para1=a0
para2=b2
MESSAGE 3
para2=b3
para3=c0

FIG. 1

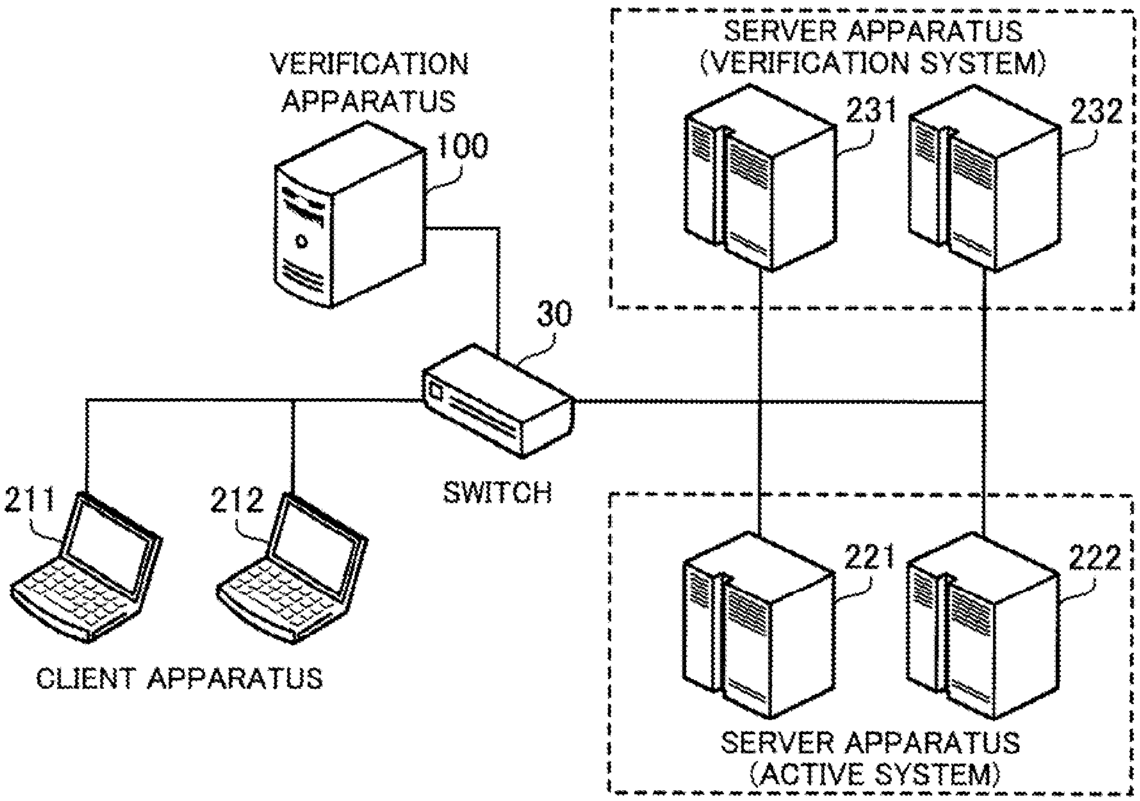

VERIFICATION APPARATUS
100
SERVER APPARATUS (VERIFICATION SYSTEM)
231
232
30
SWITCH
211
212
CLIENT APPARATUS
221
222
SERVER APPARATUS (ACTIVE SYSTEM)

FIG. 2

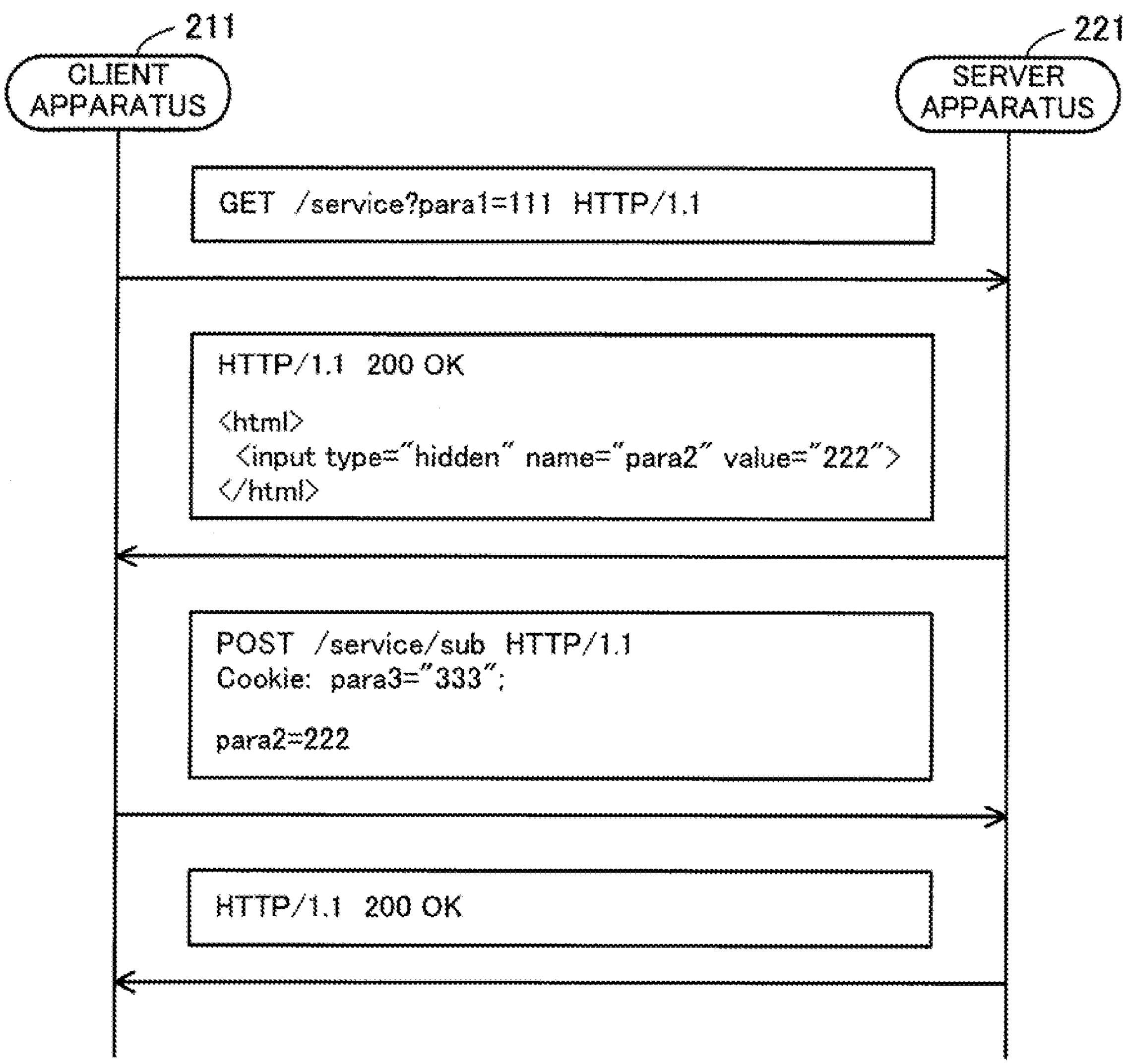

211
CLIENT APPARATUS
221
SERVER APPARATUS
GET /service?para1=111 HTTP/1.1
HTTP/1.1 200 OK
<html>
<input type="hidden" name="para2" value="222">
</html>
POST /service/sub HTTP/1.1
Cookie: para3="333";
para2=222
HTTP/1.1 200 OK

FIG. 3

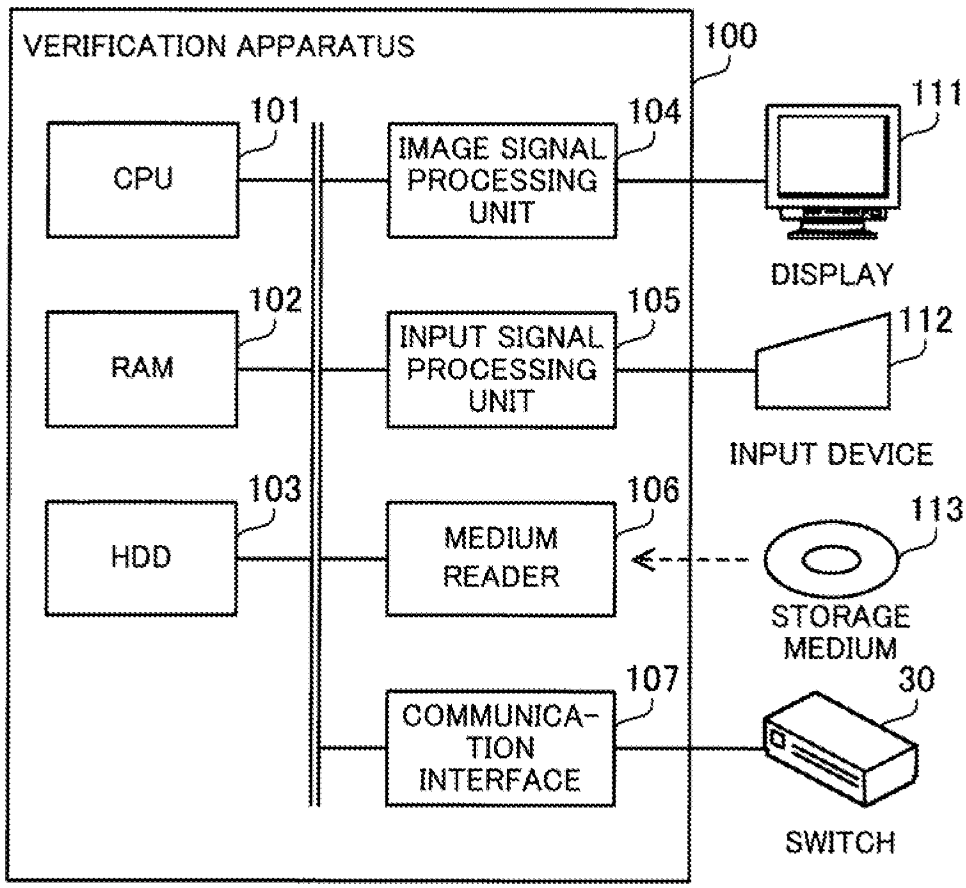

VERIFICATION APPARATUS
100
101
CPU
102
RAM
103
HDD
104
IMAGE SIGNAL PROCESSING UNIT
105
INPUT SIGNAL PROCESSING UNIT
106
MEDIUM READER
107
COMMUNICA-TION INTERFACE
111
DISPLAY
112
INPUT DEVICE
113
STORAGE MEDIUM
30
SWITCH

FIG. 4

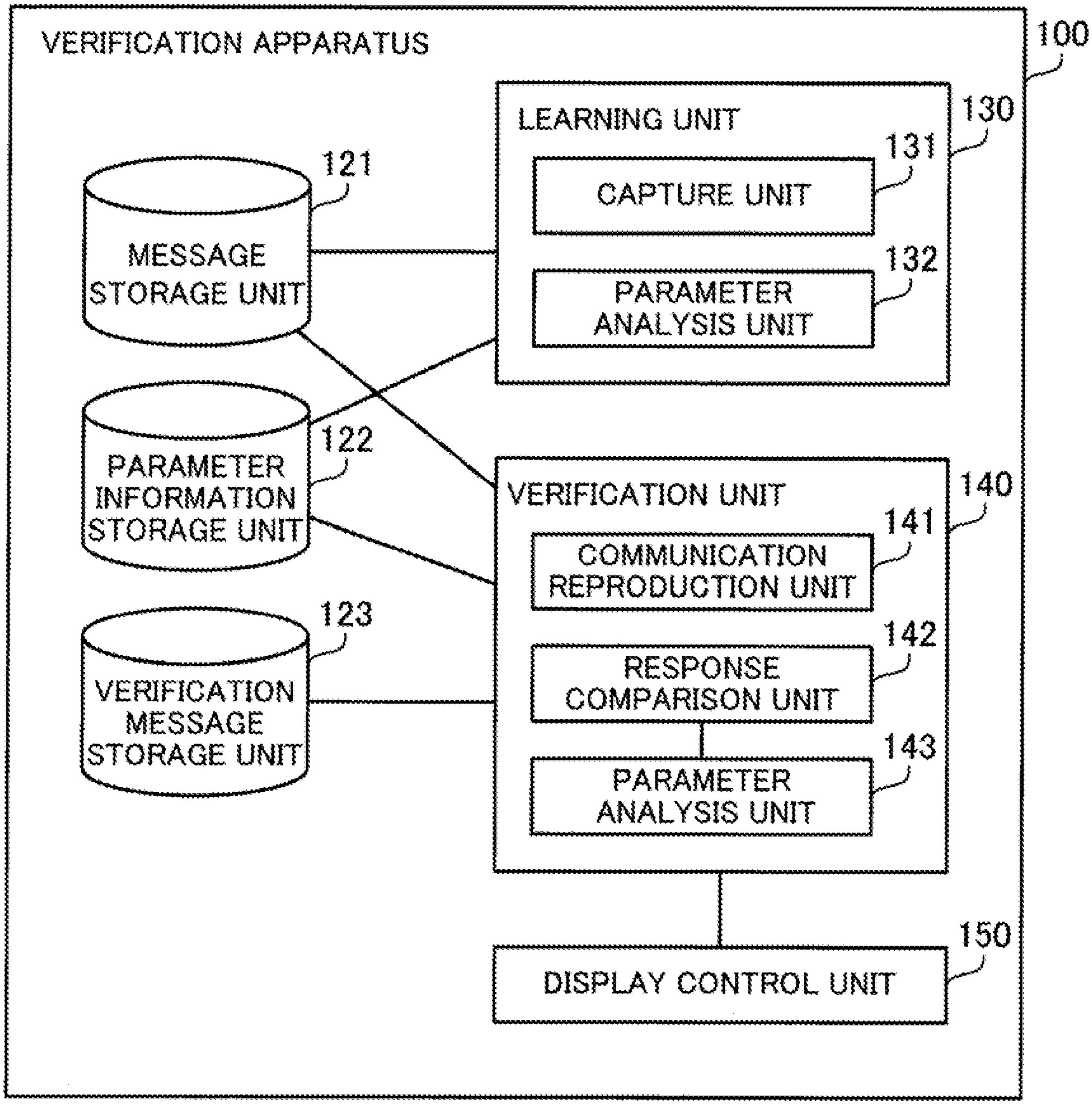

VERIFICATION APPARATUS
100
LEARNING UNIT
130
131
CAPTURE UNIT
132
PARAMETER ANALYSIS UNIT
121
MESSAGE STORAGE UNIT
122
PARAMETER INFORMATION STORAGE UNIT
123
VERIFICATION MESSAGE STORAGE UNIT
VERIFICATION UNIT
140
141
COMMUNICATION REPRODUCTION UNIT
142
RESPONSE COMPARISON UNIT
143
PARAMETER ANALYSIS UNIT
150
DISPLAY CONTROL UNIT

FIG. 5

MESSAGE TABLE

124

| No | TIME | TRANSMISSION SOURCE ADDRESS | DESTINATION ADDRESS | METHOD/CODE | PATH | PARAMETER 1 | PARAMETER 2 |
|---|---|---|---|---|---|---|---|
| 1 | 13:00:00.000 | XX.2.1.100 | XX.1.1.10 | GET | /service | version=1.0 | — |
| 2 | 13:00:00.001 | XX.1.1.10 | XX.2.1.100 | 200 OK | — | auth_token=0fa5 | — |
| 3 | 13:00:00.021 | XX.2.1.100 | XX.1.1.10 | POST | /service/login | auth_token=0fa5 | user=Taro |
| 4 | 13:00:00.022 | XX.1.1.10 | XX.2.1.100 | 200 OK | — | — | — |
| 5 | 13:00:01.000 | XX.2.1.100 | XX.1.1.10 | GET | /service | version=1.0 | — |
| 6 | 13:00:01.001 | XX.1.1.10 | XX.2.1.100 | 200 OK | — | auth_token=3b2c | — |
| 7 | 13:00:01.021 | XX.2.1.100 | XX.1.1.10 | POST | /service/login | auth_token=3b2c | user=Taro |
| 8 | 13:00:01.022 | XX.1.1.10 | XX.2.1.100 | 200 OK | — | — | — |
| 9 | 13:00:02.000 | XX.2.1.105 | XX.1.1.10 | GET | /service | version=1.0 | — |
| 10 | 13:00:02.001 | XX.1.1.10 | XX.2.1.105 | 200 OK | — | auth_token=d97e | — |
| 11 | 13:00:02.021 | XX.2.1.105 | XX.1.1.10 | POST | /service/login | auth_token=d97e | user=Jiro |
| 12 | 13:00:02.022 | XX.1.1.10 | XX.2.1.105 | 200 OK | — | — | — |

FIG. 6

PARAMETER DETECTION TABLE

125

| CLIENT ADDRESS | PARAMETER NAME | VALUE |
|---|---|---|
| XX.2.1.100 | version | 1.0 |
| XX.2.1.100 | auth_token | 0fa5 |
| XX.2.1.100 | user | Taro |
| XX.2.1.105 | version | 1.0 |
| XX.2.1.105 | auth_token | d97e |
| XX.2.1.105 | user | Jiro |

FIG. 7

ANALYSIS RESULT TABLE

126

| DETERMINATION RESULT | PARAMETER NAME | REWRITING METHOD |
|---|---|---|
| DEPENDENT | auth_token | VALUE OF <input type="hidden" name="auth_token"> OF IMMEDIATELY PRECEDING RESPONSE MESSAGE |
| INDEPENDENT | version | — |

FIG. 8

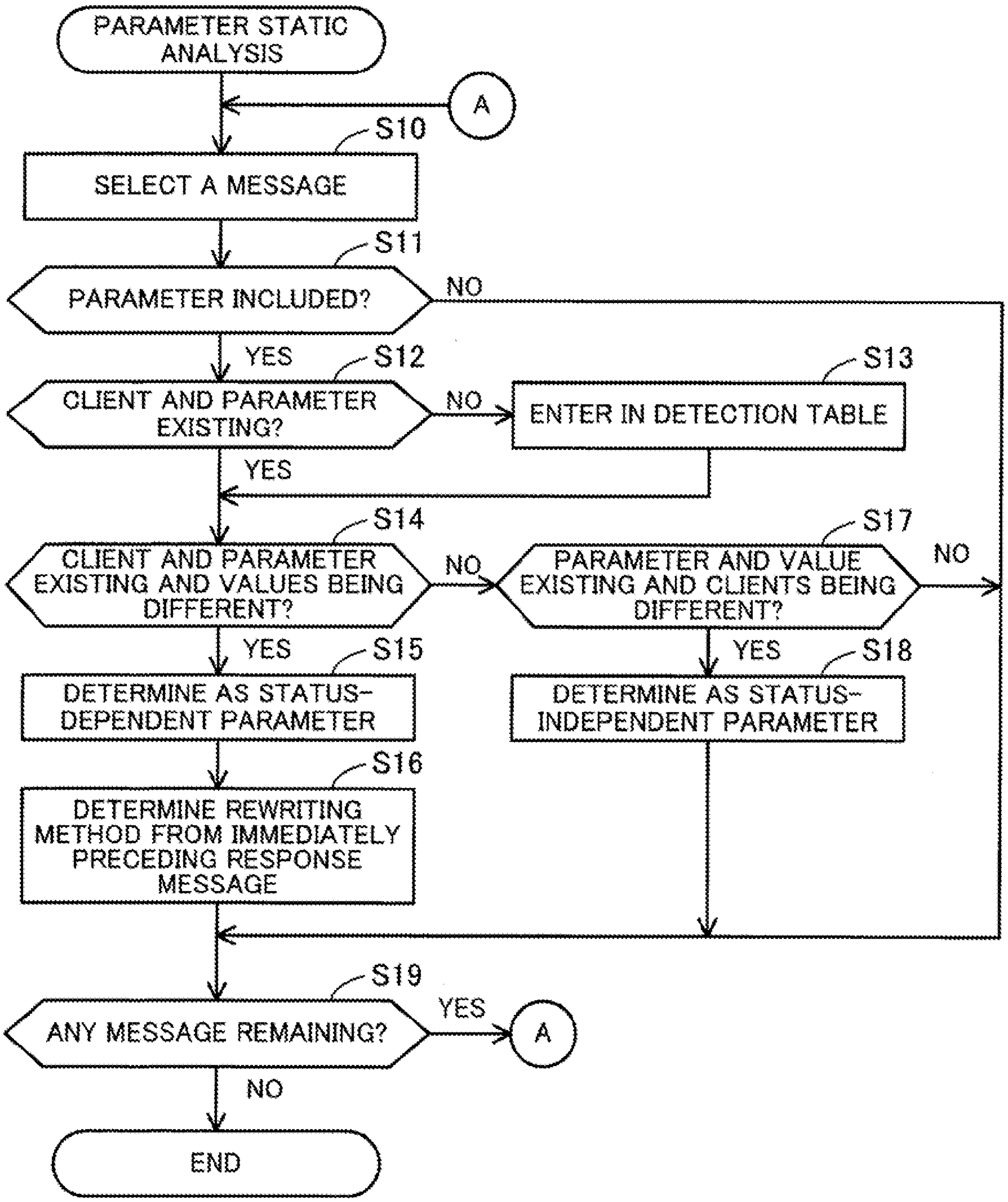

PARAMETER STATIC ANALYSIS
A
S10
SELECT A MESSAGE
S11
PARAMETER INCLUDED?
NO
YES
S12
CLIENT AND PARAMETER EXISTING?
NO
S13
ENTER IN DETECTION TABLE
YES
S14
CLIENT AND PARAMETER EXISTING AND VALUES BEING DIFFERENT?
NO
S17
PARAMETER AND VALUE EXISTING AND CLIENTS BEING DIFFERENT?
NO
YES
S15
DETERMINE AS STATUS-DEPENDENT PARAMETER
YES
S18
DETERMINE AS STATUS-INDEPENDENT PARAMETER
S16
DETERMINE REWRITING METHOD FROM IMMEDIATELY PRECEDING RESPONSE MESSAGE
S19
ANY MESSAGE REMAINING?
YES
A
NO
END

FIG. 9

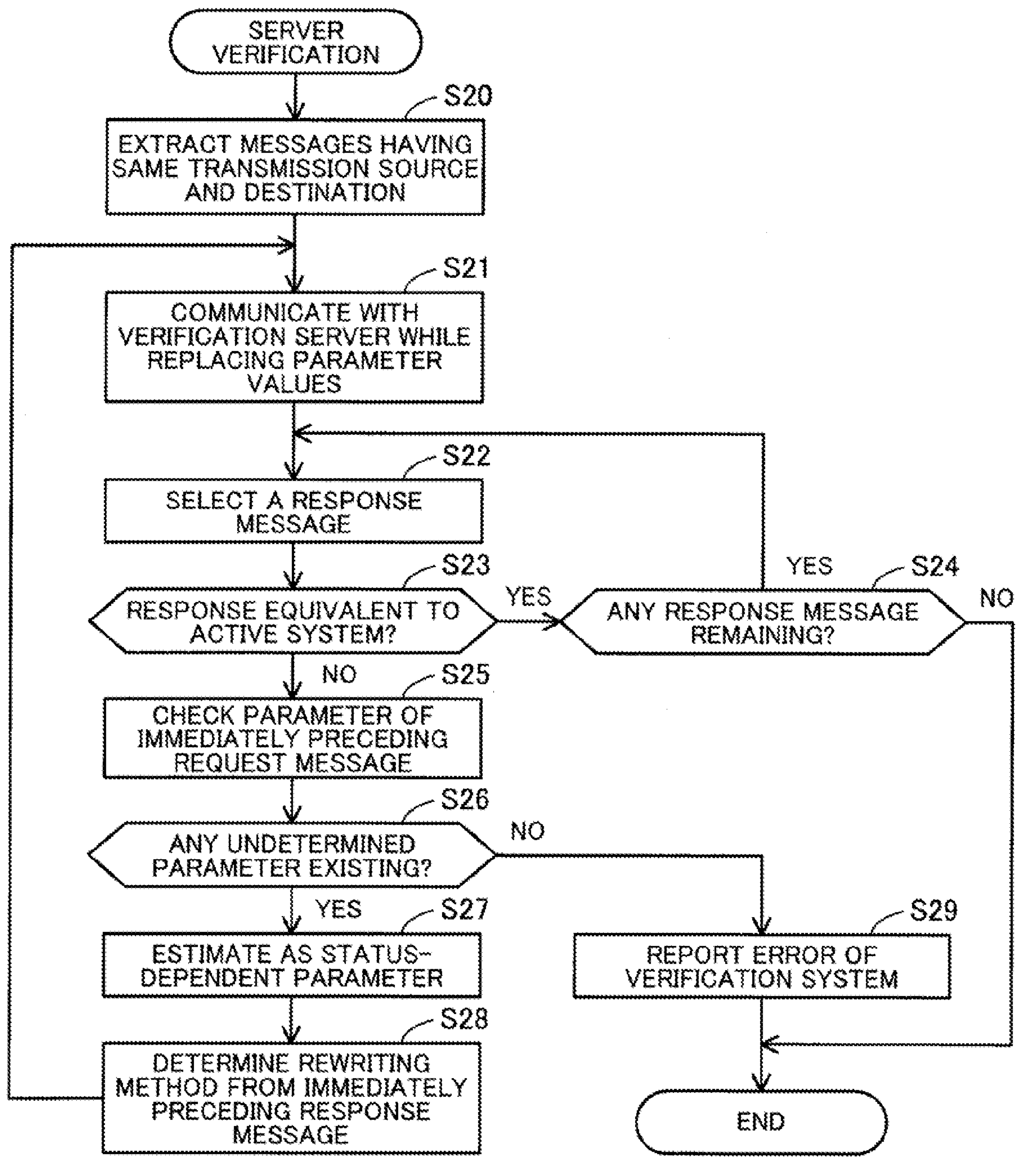

SERVER VERIFICATION
S20
EXTRACT MESSAGES HAVING SAME TRANSMISSION SOURCE AND DESTINATION
S21
COMMUNICATE WITH VERIFICATION SERVER WHILE REPLACING PARAMETER VALUES
S22
SELECT A RESPONSE MESSAGE
S23
RESPONSE EQUIVALENT TO ACTIVE SYSTEM?
YES
S24
ANY RESPONSE MESSAGE REMAINING?
YES
NO
NO
S25
CHECK PARAMETER OF IMMEDIATELY PRECEDING REQUEST MESSAGE
S26
ANY UNDETERMINED PARAMETER EXISTING?
NO
YES
S27
ESTIMATE AS STATUS-DEPENDENT PARAMETER
S28
DETERMINE REWRITING METHOD FROM IMMEDIATELY PRECEDING RESPONSE MESSAGE
S29
REPORT ERROR OF VERIFICATION SYSTEM
END

FIG. 10

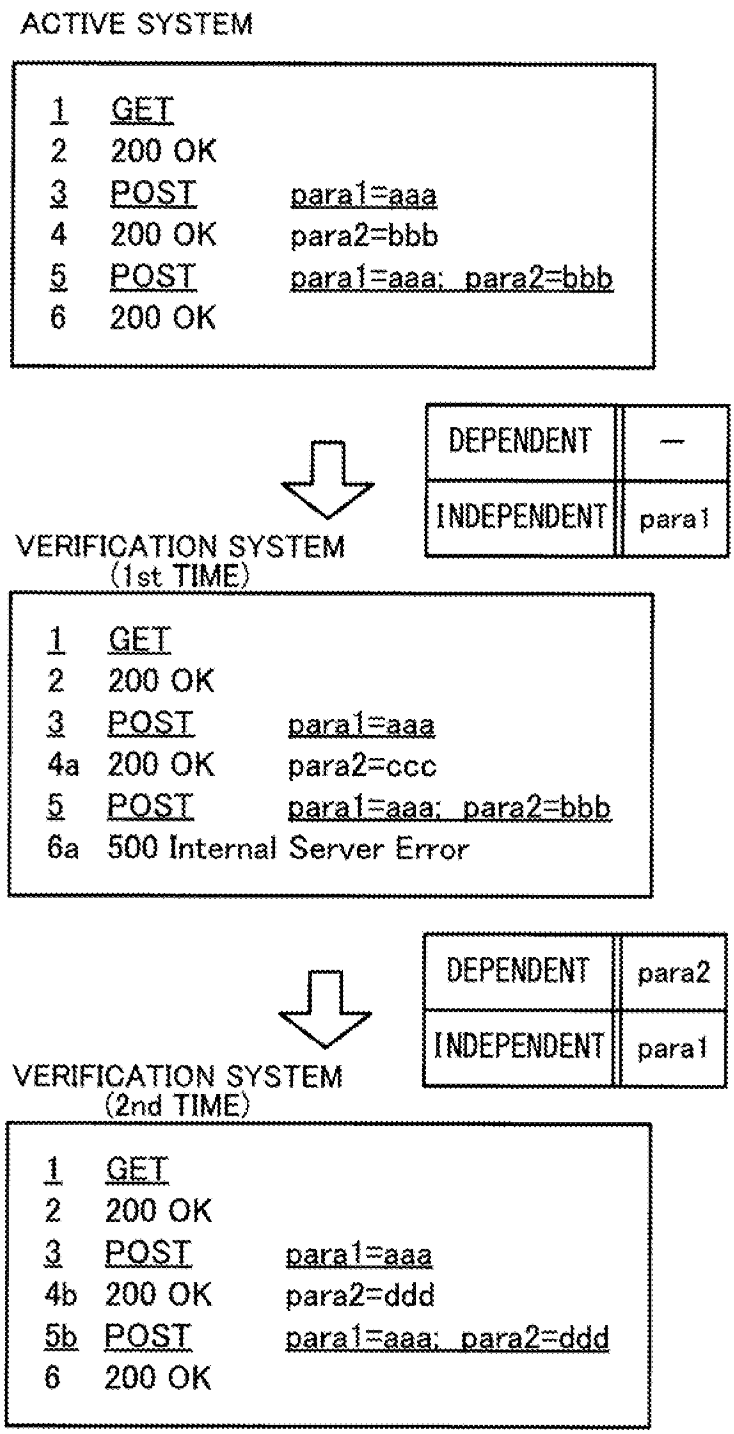

ACTIVE SYSTEM
1 GET
2 200 OK
3 POST para1=aaa
4 200 OK para2=bbb
5 POST para1=aaa; para2=bbb
6 200 OK
DEPENDENT —
INDEPENDENT para1
VERIFICATION SYSTEM (1st TIME)
1 GET
2 200 OK
3 POST para1=aaa
4a 200 OK para2=ccc
5 POST para1=aaa; para2=bbb
6a 500 Internal Server Error
DEPENDENT para2
INDEPENDENT para1
VERIFICATION SYSTEM (2nd TIME)
1 GET
2 200 OK
3 POST para1=aaa
4b 200 OK para2=ddd
5b POST para1=aaa; para2=ddd
6 200 OK

FIG. 11

MESSAGE TABLE

124

| No | METHOD/CODE | PARAMETER 1 | PARAMETER 2 |
|---|---|---|---|
| 1 | GET | version=1.0 | — |
| 2 | 200 OK | auth_token=0fa5 | — |
| 3 | POST | auth_token=0fa5 | user=Taro |
| 4 | 200 OK | — | — |
| 5 | GET | version=1.0 | — |
| 6 | 200 OK | auth_token=3b2c | — |
| 7 | POST | auth_token=3b2c | user=Taro |
| 8 | 200 OK | — | — |
| 9 | GET | version=1.0 | — |
| 10 | 200 OK | auth_token=d97e | — |
| 11 | POST | auth_token=d97e | user=Jiro |
| 12 | 200 OK | — | — |

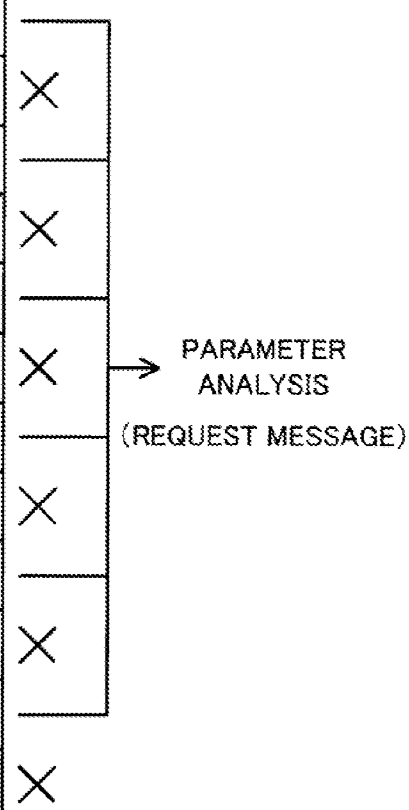



FIG. 12

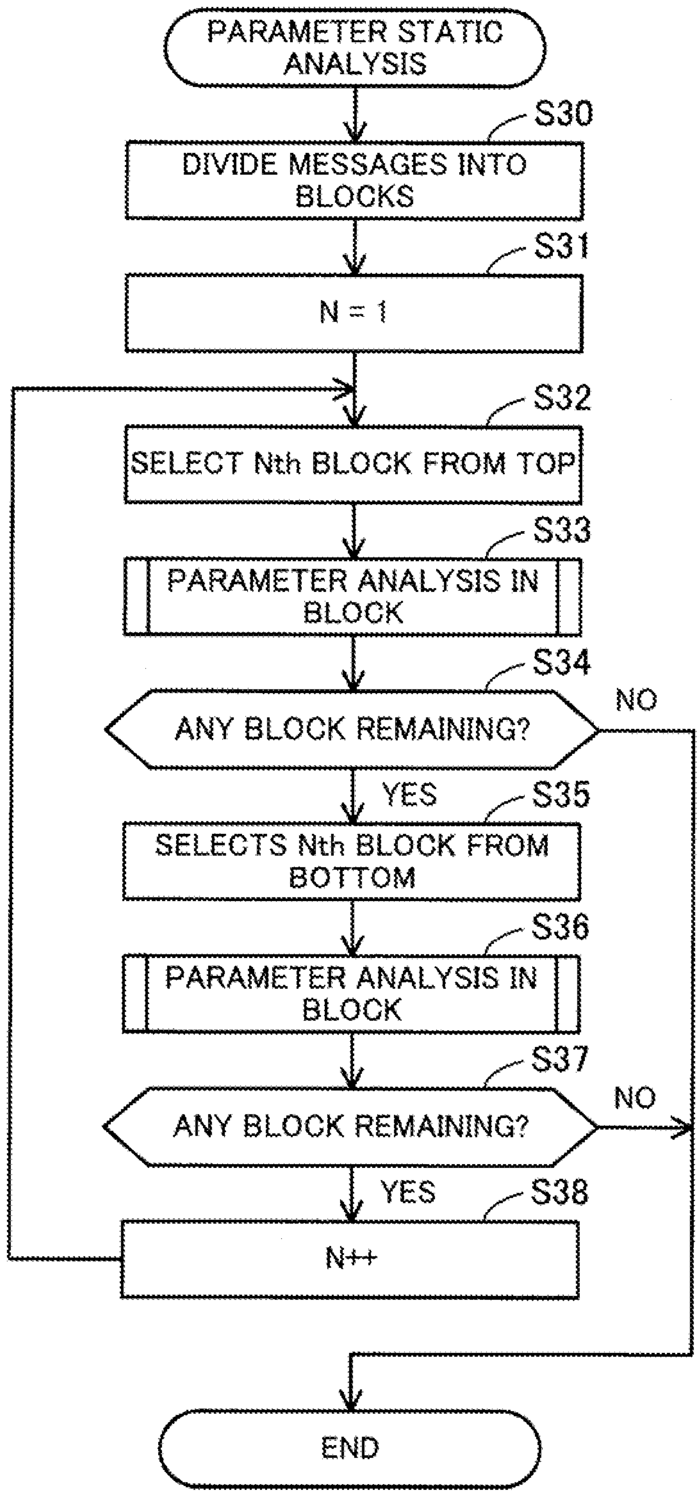

PARAMETER STATIC ANALYSIS
S30
DIVIDE MESSAGES INTO BLOCKS
S31
N = 1
S32
SELECT Nth BLOCK FROM TOP
S33
PARAMETER ANALYSIS IN BLOCK
S34
ANY BLOCK REMAINING?
NO
YES
S35
SELECTS Nth BLOCK FROM BOTTOM
S36
PARAMETER ANALYSIS IN BLOCK
S37
ANY BLOCK REMAINING?
NO
YES
S38
N++
END

FIG. 13

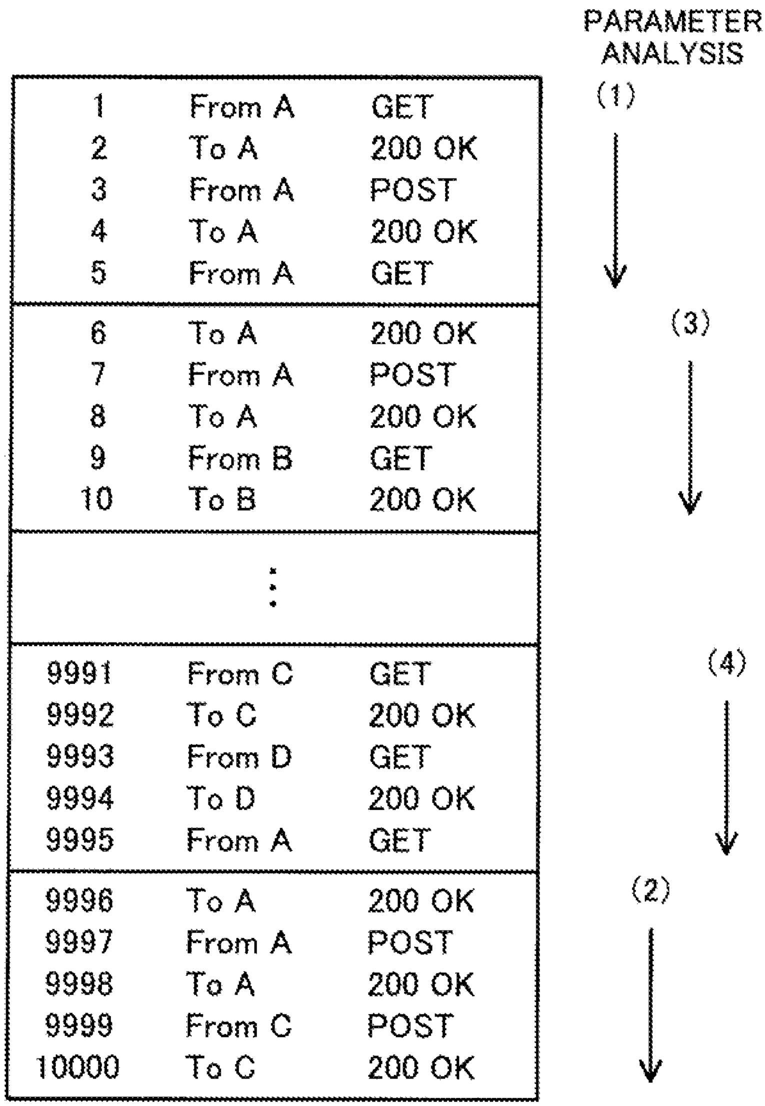

PARAMETER ANALYSIS
(1)
(3)
(4)
(2)
1 From A GET
2 To A 200 OK
3 From A POST
4 To A 200 OK
5 From A GET
6 To A 200 OK
7 From A POST
8 To A 200 OK
9 From B GET
10 To B 200 OK
⋮
9991 From C GET
9992 To C 200 OK
9993 From D GET
9994 To D 200 OK
9995 From A GET
9996 To A 200 OK
9997 From A POST
9998 To A 200 OK
9999 From C POST
10000 To C 200 OK

FIG. 14

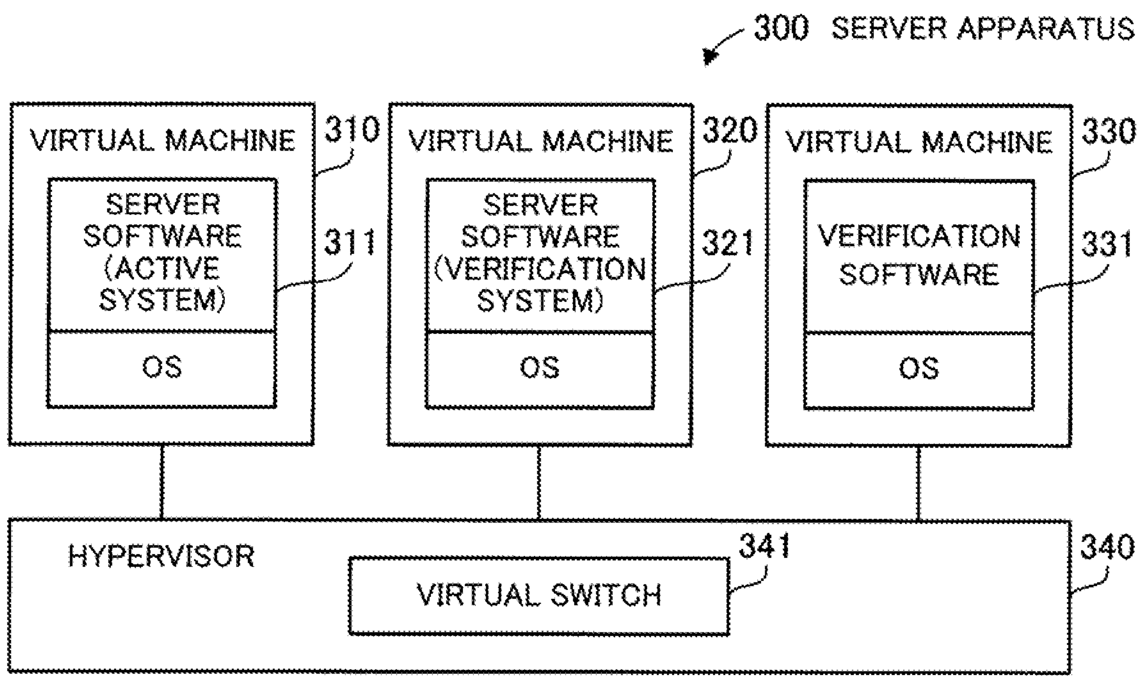

300 SERVER APPARATUS
VIRTUAL MACHINE
310
SERVER SOFTWARE (ACTIVE SYSTEM)
311
OS
VIRTUAL MACHINE
320
SERVER SOFTWARE (VERIFICATION SYSTEM)
321
OS
VIRTUAL MACHINE
330
VERIFICATION SOFTWARE
331
OS
HYPERVISOR
341
VIRTUAL SWITCH
340

FIG. 15

# INFORMATION PROCESSING APPARATUS AND VERIFICATION CONTROL METHOD

## CROSS-REFERENCE TO RELATED APPLICATION

This application is based upon and claims the benefit of priority of the prior Japanese Patent Application No. 2013-067791, filed on Mar. 28, 2013, the entire contents of which are incorporated herein by reference.

## FIELD

The embodiments discussed herein relate to an information processing apparatus and a verification control method.

## BACKGROUND

It may be desired, in a process of operating or maintaining an information processing system, to verify whether or not a computer and another computer have the equivalent function. For example, there may be a case of verifying, before replacing a currently used computer with a new computer, whether or not the function of the original computer is also realized in the new computer. In addition, for example, a degradation test may be performed before updating software of a computer, in which the software is experimentally updated on a computer for testing to check whether or not operation of another software varies due to influence of the update. In addition, for example, when any failure occurs in a computer for business operation, there may be a case of reproducing the failure on a computer for debugging to analyze a cause of the failure.

As a computer to be verified, a server is conceivable, which receives a request message from a client and transmits a response message to the client according to the request message. The client and the server may be a physical computer (also referred to as a physical machine), or may be a virtual computer (also referred to as a virtual machine). In this case, a black-box verification method, which uses messages transmitted between a server and a client in the past to verify another server, may be employed as the verification method.

For example, a verification apparatus obtains a request message transmitted from a client to a server in the past and a response message transmitted from the server to the client in the past. The verification apparatus transmits the obtained past request message to another server and receives, from the other server, a response message to the request message. The verification apparatus then determines whether or not a function equivalent to that of the original server is realized in the other server by comparing the response message received from the other server with the obtained past response message.

There is proposed a test apparatus which evaluates the relative performance of a standby server with respect to an active server by capturing packets transmitted to and from the active server and transferring the captured packets to the standby server. In addition, there is proposed a test platform apparatus for testing a Web application in which a parameter name in a Web page provided to a client varies for each access from the client. The test platform apparatus preliminarily stores a parameter definition rule which defines a parameter whose name varies. The test platform apparatus extracts from a Web page a parameter which complies with the parameter definition rule, and substitutes the name and the value of the extracted parameter with a predetermined name and a predetermined value, thereby enabling an automatic test tool operating on the client to process the Web page.

Japanese Patent Laid-open Patent Publication No. 2011-199680

Japanese Patent Laid-open Patent Publication No. 2010-113380

Meanwhile, when a server and another server operate according to a value of a parameter included in a request message, directly using a request message transmitted between a client and a server in the past may result in incorrect verification of another server.

For example, the client may transmit, to the server, a request message including a value of a parameter which depends on a session such as a session ID or authentication information. In such a case, in response to transmission of the past request message without change to the other server, the other server may regard the value of the parameter as an abnormal value related to a non-existent session and return an error to the client. In addition, for example, the client may transmit a request message including a value of a parameter which depends on a physical state of the server, such as the MAC (Media Access Control) address of the server. Also in such a case, in response to transmission of the past request message without change to the other server, the other server may determine the value of the parameter to be inappropriate and return an error to the client.

Therefore, it is conceivable, when using messages transmitted between a server and a client in the past, to rewrite at least a part of the values of parameters included in the message. However, there is a problem that preliminarily defining, by a user instructing verification, a parameter whose value is to be rewritten among parameters that may be included in the messages imposes a large burden on the user. This is because it is difficult to accurately define a parameter whose value is to be rewritten, unless the user knows the details of the software that performs message processing.

## SUMMARY

According to an aspect, there is provided an information processing apparatus including a memory configured to store a plurality of messages transmitted between a client and one more servers, each message including at least one of a plurality of parameters and a value of the parameter, and a processor configured to detect, among the plurality of parameters, a parameter having different values set in different messages and, according to the detection result, determine a rewrite parameter whose value is rewritten when using the plurality of messages for verification of another server, among the plurality of parameters.

The object and advantages of the invention will be realized and attained by means of the elements and combinations particularly pointed out in the claims.

It is to be understood that both the foregoing general description and the following detailed description are exemplary and explanatory and are not restrictive of the invention.

## BRIEF DESCRIPTION OF DRAWINGS

FIG. **1** illustrates an information processing system of a first embodiment;

FIG. **2** illustrates an information processing system of a second embodiment;

FIG. **3** illustrates exemplary parameters included in messages;

FIG. **4** is a block diagram illustrating an exemplary hardware of a verification apparatus;

FIG. **5** is a block diagram illustrating an exemplary function of the verification apparatus;

FIG. **6** illustrates an exemplary message table;

FIG. **7** illustrates an exemplary parameter detection table;

FIG. **8** illustrates an exemplary analysis result table;

FIG. **9** is a flow chart illustrating an exemplary procedure of parameter static analysis;

FIG. **10** is a flow chart illustrating an exemplary procedure of server verification;

FIG. **11** illustrates an exemplary verification message;

FIG. **12** illustrates a first example of a message selection method;

FIG. **13** is a flow chart illustrating another exemplary procedure of the parameter static analysis;

FIG. **14** illustrates a second example of the message selection method; and

FIG. **15** is a block diagram illustrating another exemplary function of the server apparatus.

## DESCRIPTION OF EMBODIMENTS

Several embodiments will be described below with reference to the accompanying drawings, wherein like reference numerals refer to like elements throughout.

### First Embodiment

FIG. **1** illustrates an information processing system of a first embodiment.

The information processing system of the first embodiment includes an information processing apparatus **10**, a client **21**, and servers **22** and **23**. The information processing system uses messages transmitted between the client **21** and one or more servers including the server **22** to verify operation of one or more servers including the server **23**. As the server **23**, for example, there are conceivable a new server scheduled to replace the server **22**, a server for testing, before updating software of the server **22**, the operation after the update, a server for debugging for reproducing a failure occurred in the server **22** to analyze the cause thereof, or the like.

The client **21** and the servers **22** and **23** may be physical machines, or may be virtual machines. In the former case, for example, the information processing apparatus **10**, the client **21** and the servers **22** and **23** are connected to a network having a communication apparatus such as a switch. In the latter case, two or more of the client **21** and the servers **22** and **23** may operate on the same physical machine. The physical machine on which a virtual machine operates may be the information processing apparatus **10**.

The information processing apparatus **10** has a storage unit **11** and a determination unit **12**. The storage unit **11** may be a volatile storage apparatus such as a RAM (Random Access Memory), or may be a nonvolatile storage apparatus such as an HDD (Hard Disk Drive). The determination unit **12** is realized using a processor, for example. The determination unit **12** may include a CPU (Central Processing Unit), a DSP (Digital Signal Processor), an ASIC (Application Specific Integrated Circuit), an FPGA (Field-Programmable Gate Array), and the like. When a processor is used, the processor executes a program to perform the procedure described below, for example.



The storage unit **11** stores a plurality of messages transmitted between the client **21** and one or more servers including the server **22**. Each message includes at least one of a plurality of parameters and a value of the parameter. Messages to be stored in the storage unit **11** are collected, for example, by capturing, by the information processing apparatus **10**, packets transmitted between the client **21** and the server **22**. The messages to be collected may be limited to messages relating to a predetermined protocol such as the HTTP (Hypertext Transfer Protocol).

For example, the plurality of messages to be stored in the storage unit **11** includes messages 1 to 3 transmitted from the client **21** to the server **22**. As a pair of a parameter name and a parameter value, the message 1 includes para1=a0, the message 2 includes para1=a0 and para2=b0, and the message 3 includes para2=b1 and para3=c0. In other words, para1 is included in the messages 1 and 2, with the value thereof being the same for the message 1 and the message 2. Although para2 is included in the messages 2 and 3, the value thereof is different between the message 2 and the message 3. Here, the parameters are application layer parameters such as those described in the HTTP header and the HTTP body, for example.

The determination unit **12** detects, from messages stored in the storage unit **11**, a parameter having different values set in different messages among a plurality of parameters that may be included in the messages. The determination unit **12** then determines, according to the detection result, a rewrite parameter whose value is rewritten when using messages stored in the storage unit **11** for verification of the server **23** (or, a plurality of servers including the server **23**). For example, the determination unit **12** determines, as the rewrite parameter, a parameter having different values set in different messages transmitted or received by the same client (the client **21**). In the case of the above example, the determination unit **12** determines para2 as the rewrite parameter, among para1, para2 and para3.

The determination unit **12** may detect a parameter satisfying the condition described above, referring only to a request message (or referring preferentially to a request message) among a request message transmitted by the client **21** and a response message transmitted by the server **22**. In addition, the determination unit **12** may detect a parameter satisfying the condition described above by referring to a plurality of messages stored in the storage unit **11** in a different order from the transmission order. For example, the determination unit **12** may perform a comparison of parameters included in messages which are separated from each other in terms of a transmission timing more preferentially than a comparison of parameters included in messages which are close to each other in terms of the transmission timing.

Subsequently, the value of the determined rewrite parameter is rewritten when verifying the server (or, a plurality of servers including the server **23**). For example, para2 is determined as the rewrite parameter, whereas para1 and para3 are determined as non-rewrite parameters whose values are not rewritten. Accordingly, for example, the message 1 including para1=a0 is transmitted to the server **23**, the message 2 including para1=a0 and para2=b2 is transmitted to the server **23**, and the message 3 including para2=b3 and para3=c0 is transmitted to the server **23**.

The value of a rewrite parameter (e.g., b2 or b3 described above) may be automatically calculated during the process of verifying the server **23**. The determination unit **12** may determine the method of rewriting the value, based on a response message transmitted before a request message including the rewrite parameter (e.g., a response message immediately before the request message), among messages stored in the storage unit **11**. In such a case, the value of a parameter of a request message transmitted to the server **23** thereafter is rewritten, based on the response message transmitted by the server **23** during the process of verification. Verification of the server **23** may be performed by the information processing apparatus **10** or another information processing apparatus.

According to the information processing system of the first embodiment, it is possible to determine a parameter whose value is to be rewritten, such as a parameter which depends on the session or a parameter which depends on the physical state of the server, from among parameters that may be included in a message. Therefore, when verifying the server **23** using messages transmitted between the client **21** and the server **22**, it becomes possible to prevent incorrect verification due to parameter abnormality. In addition, the user need not preliminarily define the parameter whose value is to be rewritten and therefore the user need not know the details of the software to be executed on the server **23**, and thereby the burden of the user is reduced.

## Second Embodiment

FIG. **2** illustrates an information processing system of a second embodiment.

The information system of the second embodiment has a switch **30**, a verification apparatus **100**, client apparatuses **211** and **212**, and server apparatuses **221**, **222**, **231** and **232**.

The switch **30** is a communication apparatus which transfers packets. The switch **30** has a port mirroring function which copies packets passing through a particular normal port or all normal ports, and outputs the copied packets from a mirror port which is different from the normal port. The verification apparatus **100** is connected to the mirror port. The switch **30** copies packets transmitted between the client apparatuses **211** and **212** and the server apparatuses **221** and **222**, and transmits the copied packets to the verification apparatus **100**. As a method of capturing packets by the verification apparatus **100**, the method may use a tap which copies a signal on a transmission medium in place of the switch **30**.

The client apparatuses **211** and **212** are client computers each as a terminal apparatus operated by a user. The server apparatuses **221**, **222**, **231** and **232** are server computers, each configured to receive a request message, perform a process according to the request message, and return a response message. In the second embodiment, a Web server which performs HTTP communication is mainly assumed as the server apparatuses **221**, **222**, **231** and **232**. However, the server apparatuses **221**, **222**, **231** and **232** may be other types of server computers.

The server apparatuses **221** and **222** among the above-mentioned server apparatuses are active server apparatuses which are currently used for business operation. The server apparatuses **221** and **222** receive a request message (e.g., HTTP request) from the client apparatuses **211** and **212**, and transmit a response message (e.g., HTTP response) to the client apparatuses **211** and **212**.

On the other hand, the server apparatuses **231** and **232** are verification server apparatuses which are not currently used for business operation. For example, as the server apparatuses **231** and **232**, a server apparatus is conceivable which is scheduled to replace the server apparatuses **221** and **222** (to be used for business operation after system migration). In addition, for example, as the server apparatuses **231** and **232**, a server apparatus for testing is conceivable which checks, before updating software of the server apparatuses **221** and **222**, the operation after the update. In addition, for example, as the server apparatuses **231** and **232**, a server apparatus for debugging is conceivable which analyzes failures occurred in the server apparatuses **221** and **222**. The server apparatuses **231** and **232** receive a request message from the verification apparatus **100** and transmit a response message to the verification apparatus **100**.

The verification apparatus **100** is a computer which verifies the server apparatuses **231** and **232** in a black-box manner, using messages transmitted between the client apparatuses **211** and **212** and the server apparatuses **221** and **222**. The verification apparatus **100** may be a terminal apparatus operated by a user, or may be a server apparatus accessed from a terminal apparatus.

In verifying the server apparatuses **231** and **232**, the verification apparatus **100** captures packets received from the switch **30**, and extracts, from the captured packets, past messages (e.g., HTTP message) transmitted or received by the server apparatuses **221** and **222**. The verification apparatus **100** transmits the extracted past request messages to the server apparatuses **231** and **232**, and receives response messages from the server apparatuses **231** and **232**. The verification apparatus **100** then compares the response messages received from the server apparatuses **231** and **232** with the past response messages, and thereby verifies whether or not the operation of the server apparatuses **231** and **232** observed from the client apparatuses **211** and **212** is equivalent to that of the server apparatuses **221** and **222**.

However, a message transmitted between the client apparatuses **211** and **212** and the server apparatuses **221** and **222** may include a parameter which depends on the communication status such as a session-dependent parameter or a server-apparatus-dependent parameter. In response to transmission of the past request message without change including a communication-status-dependent parameter to the server apparatuses **231** and **232**, the server apparatuses **231** and **232** may reject the request message, by determining the session or the server apparatus indicated by the value of the parameter to be inappropriate. Therefore, the verification apparatus **100** determines a status-dependent parameter from among parameters which may be included in the messages, and rewrites the value of the status-dependent parameter included in the request message as appropriate, according to the communication status with the server apparatuses **231** and **232**.

FIG. **3** illustrates exemplary parameters included in messages.

Here, consider a case where an HTTP message is transmitted between the client apparatus **211** and the server apparatus **221**. The verification apparatus **100** determines a status-dependent parameter from among parameters included in the header and the body of the HTTP message.

The name and the value of the parameter may be added to the URL (Uniform Resource Locator) described in the header of the HTTP request. For example, when the URL has a description /service?para1=111, para1 is the parameter name and 111 is the value thereof. In addition, the name and the value of the parameter may be described as a Cookie in the header of the HTTP request. For example, when a Cookie has a description para3="333", para3 is the parameter name and 333 is the value thereof.

In addition, the name and the value of the parameter may be described as input data of the POST method in the body of the HTTP request. For example, when the input data has a description para2=222, para2 is the parameter name and

222 is the value thereof. In addition, the name and the value of the parameter may be included in the HTML (Hypertext Markup Language) tag described in the body of the HTTP response. For example, when the HTML tag has a description <input type="hidden" name="para2" value="222">, para2 is the parameter name and 222 is the value thereof.

The value of the parameter included in the HTTP response received by the client apparatus **211** before the HTTP request may be used as the value of the parameter included in the HTTP request transmitted by the client apparatus **211**. For example, it is assumed that an HTTP response including para2=222 is transmitted to the client apparatus **211** from the server apparatus **221**. In such a case, an HTTP request transmitted immediately thereafter from the client apparatus **211** to the server apparatus **221** may include para2=222.

As has been described above, the parameters may include a status-dependent parameter such as a session-dependent parameter or a server-apparatus-dependent parameter. A parameter indicating the session ID or authentication information may be cited as an example of a session-dependent parameter.

The session ID varies for each session as a general rule, and the authentication information varies, as a general rule, each time the server apparatus **221** performs authentication. For example, the server apparatus **221** transmits an HTTP response including a session ID to the client apparatus **211**, and the client apparatus **211** transmits an HTTP request including the session ID to the server apparatus **221**, which allows the server apparatus **221** to identify the session to which the HTTP request belongs. A physical address such as the MAC address may be cited as an example of a server-apparatus-dependent parameter. The value of the server-apparatus-dependent parameter varies according to the access destination server apparatus.

FIG. **4** is a block diagram illustrating an exemplary hardware of the verification apparatus.

The verification apparatus **100** has a CPU **101**, a RAM **102**, an HDD **103**, an image signal processing unit **104**, an input signal processing unit **105**, a medium reader **106**, and a communication interface **107**. The CPU **101** is an example of the determination unit **12** of the first embodiment, and the RAM **102** or the HDD **103** is an example of the storage unit **11** of the first embodiment.

The CPU **101** is a processor including an operational circuit which executes instructions of programs. The CPU **101** loads at least a part of a program and data stored in the HDD **103** into the RAM **102**, and executes the program. The CPU **101** may include a plurality of processor cores and the verification apparatus **100** may include a plurality of processors, and accordingly the procedure described below may be performed in parallel using the plurality of processors or processor cores. In addition, a set of processors (multiprocessors) may be referred to as a "processor".

The RAM **102** is a volatile memory which temporarily stores programs executed by the CPU **101** or data which is used by the CPU **101** for calculation. The verification apparatus **100** may include any type of memory other than a RAM, and may include a plurality of memories.

The HDD **103** is a nonvolatile storage apparatus which stores software programs such as the OS (Operating System) and application software, and also stores data. The verification apparatus **100** may include another type of storage apparatus such as a flash memory or an SSD (Solid State Drive), and may include a plurality of nonvolatile storage apparatuses.

The image signal processing unit **104** outputs images to a display **111** connected to the verification apparatus **100**, according to an instruction from the CPU **101**. A CRT (Cathode Ray Tube) display, a liquid crystal display (LCD), a plasma display (PDP: Plasma Display Panel), an organic EL (OELD: Organic Electro-Luminescence) display, or the like may be used as the display **111**.



The input signal processing unit **105** obtains an input signal from an input device **112** connected to the verification apparatus **100**, and outputs the input signal to the CPU **101**. A pointing device such as a mouse, touch panel, touchpad, or a track ball, a keyboard, a remote controller, a button switch, or the like may be used as the input device **112**. In addition, a plurality of types of input devices may be connected to the verification apparatus **100**.

The medium reader **106** is a drive unit which reads programs and data stored in a recording medium **113**. A magnetic disk such as a flexible disk (FD) or an HDD, an optical disk such as a CD (Compact Disc) or a DVD (Digital Versatile Disc), an MO disk (Magneto-Optical disk), a semiconductor memory, for example, may be used as the recording medium **113**. The medium reader **106** stores the programs or data which have been read from the recording medium **113**, for example, in the RAM **102** or the HDD **103**.

The communication interface **107** is an interface connected to the switch **30** to transmit and receive packets. The communication interface **107** receives, from the switch **30**, a copy of packets transmitted between the client apparatuses **211** and **212** and the server apparatuses **221** and **222**. In addition, the communication interface **107** transmits packets to the server apparatuses **231** and **232**, and receives packets from the server apparatuses **231** and **232**. The verification apparatus **100** may include a communication interface for capturing packets and, separately, a communication interface for communicating with the server apparatuses **231** and **232**.

However, the verification apparatus **100** need not include the medium reader **106**. In addition, the verification apparatus **100** need not include the image signal processing unit **104** and the input signal processing unit **105** when the verification apparatus **100** may be controlled from a terminal apparatus via a network.

FIG. **5** is a block diagram illustrating an exemplary function of the verification apparatus.

The verification apparatus **100** has a message storage unit **121**, a parameter information storage unit **122**, a verification message storage unit **123**, a learning unit **130**, a verification unit **140**, and a display control unit **150**. The message storage unit **121**, the parameter information storage unit **122**, and the verification message storage unit **123** may be realized as a storage area secured in the RAM **102** or the HDD **103**, for example. The learning unit **130**, the verification unit **140**, and the display control unit **150** may be realized as a software module executed by the CPU **101**, for example.

The message storage unit **121** stores messages or a part of information included in the messages transmitted between the client apparatuses **211** and **212** and the server apparatuses **221** and **222**. The parameter information storage unit **122** stores an analysis result of parameters included in the messages and information of the intermediate progress of the analysis. The analysis result includes information indicating a status-dependent parameter, information indicating a status-independent parameter, and information indicating a method of rewriting the value of the status-dependent parameter at the time of verification. When verifying the server apparatuses **231** and **232**, the verification message storage unit **123** stores messages or a part of information included in the messages transmitted between the verification apparatus **100** and the server apparatuses **231** and **232**.

The learning unit **130** analyzes messages transmitted between the client apparatuses **211** and **212** and the server apparatuses **221** and **222**, and learns a method of verifying the server apparatuses **231** and **232**. The learning unit **130** has a capture unit **131** and a parameter analysis unit **132**.

The capture unit **131** captures packets (e.g., IP (Internet Protocol) packets) received from the switch **30**. When packets to be copied by the switch **30** include those transmitted by a computer other than the client apparatuses **211** and **212** and the server apparatuses **221** and **222**, the capture unit **131** may limit the packets to be captured. The capture unit **131** then extracts messages from a set of captured packets and stores the messages or a part of information included in the messages in the message storage unit **121**. In this occasion, the capture unit **131** may limit the messages to be extracted to those related to the protocol (e.g., HTTP) of a predetermined application layer.

Referring to the message storage unit **121**, the parameter analysis unit **132** analyzes parameters included in messages, before verification of the server apparatuses **231** and **232** is started (static analysis). As will be described below, the parameter analysis unit **132** identifies three items: the client apparatus which transmitted or received the message, the parameter included in the message, and the value of the parameter. The parameter analysis unit **132** then determines the status-dependent parameter and the status-independent parameter, based on accordance or discordance of the above-mentioned three items among different messages. The parameter analysis unit **132** stores the analysis result in the parameter information storage unit **122**.

The verification unit **140** verifies whether or not the operation of the server apparatuses **231** and **232** are equivalent to that of the server apparatuses **221** and **222**, based on the learning result of the learning unit **130**. The verification unit **140** has a communication reproduction unit **141**, a response comparison unit **142**, and a parameter analysis unit **143**.

Referring to the message storage unit **121**, the communication reproduction unit **141** reproduces, on the server apparatuses **231** and **232**, the access from the client apparatuses **211** and **212** to the server apparatuses **221** and **222**. In other words, the communication reproduction unit **141** transmits, to the server apparatuses **231** and **232**, a request message transmitted from the client apparatuses **211** and **212** to the server apparatuses **221** and **222** in the past, with the transmission order being preserved. In this occasion, the communication reproduction unit **141** rewrites values of parameters included in the request message transmitted in the past as appropriate, based on the analysis result of parameters stored in the parameter information storage unit **122**.

In the course of verification, the communication reproduction unit **141** stores, in the verification message storage unit **123**, the request message or a part of information included in the request message transmitted to the server apparatuses **231** and **232**. In addition, the communication reproduction unit **141** stores, in the verification message storage unit **123**, the response message or a part of information included in the response message received from the server apparatuses **231** and **232** in response to the request message. However, it may be configured such that the request message or a part of information included in the request message is not stored in the verification message storage unit **123**.

Referring to the message storage unit **121** and the verification message storage unit **123**, the response comparison unit **142** compares the response message transmitted by the server apparatuses **221** and **222** in the past with the response message transmitted by the server apparatuses **231** and **232**, and determines the equivalence of the both messages. When the two response messages are not equivalent, the response comparison unit **142** calls the parameter analysis unit **143**.

In this occasion, the response messages may include session-dependent information or server-apparatus-dependent information, and therefore the response comparison unit **142** may determine that the two response messages are "equivalent" even when contents of the two response messages do not completely match. For example, the response comparison unit **142** determines that response messages having the same HTTP status code are equivalent. The HTTP status code is a code indicating the status of the server, such as a code **200** indicating the success of the HTTP request, a code **500** indicating the occurrence of an unexpected error in the server while processing an HTTP request. In addition, for example, the response comparison unit **142** determines that response messages are equivalent when similarity of character strings included in the body of the HTTP response is equal to or higher than a predetermined threshold value.

Referring to the verification message storage unit **123**, the parameter analysis unit **143** analyzes, in the course of verification (dynamic analysis), parameters included in messages transmitted between the verification apparatus **100** and the server apparatuses **231** and **232**. This is performed taking into account the possibility that not all the status-dependent parameters have been identified in the static analysis by the parameter analysis unit **132**.

In other words, when it is determined that one response message received from the server apparatuses **231** and **232** is not equivalent to a past response message corresponding thereto, the parameter analysis unit **143** assumes that this is due to rewriting failure of the value of the parameter included in the request message. Under the assumption, the parameter analysis unit **143** estimates that the parameter included in the request message transmitted before the above-mentioned one response message is a status-dependent parameter (adds a status-dependent parameter), and updates the analysis result stored in the parameter information storage unit **122**.

After the status-dependent parameter has been added, access to the server apparatuses **231** and **232** by the communication reproduction unit **141** is attempted again. When the response message received from the server apparatuses **231** and **232** is not equivalent to the past response message despite the addition of the status-dependent parameter, the parameter analysis unit **143** determines that there exists an anomaly in the server apparatuses **231** and **232**, for example. In other words, it is determined that the operation of the server apparatuses **231** and **232** observed from the client apparatuses **211** and **212** is not equivalent to that of the server apparatuses **221** and **222**.

However, before evaluating the equivalence of the operation of the server apparatuses **221** and **222** to the operation of the server apparatuses **231** and **232**, the verification unit **140** may settle the status-dependent parameter first. For example, the verification unit **140** transmits a request message to the server apparatuses **231** and **232** which have executed the same software as that of the server apparatuses **221** and **222**. The verification unit **140** keeps adding parameters estimated to be a status-dependent parameter until all the response messages being received in this occasion are equivalent to those transmitted from the server apparatuses **221** and **222** in the past. Subsequently, the verification unit **140** transmits a request message to the server apparatuses **231** and **232** which have executed software different from that of the server apparatuses **221** and **222** to evaluate the equivalence of operations.

The display control unit **150** causes the display **111** to display the verification result of the verification unit **140**.

It is assumed in the second embodiment that the verification apparatus **100** includes both the learning unit **130** and the verification unit **140**. In other words, it is assumed that the same physical machine performs both static analysis of the status-dependent parameter and verification of the server apparatuses **231** and **232**. However, static analysis of the status-dependent parameter and verification of the server apparatuses **231** and **232** may be performed by different physical machines. In such a case, for example, the result of static analysis of the parameter performed by one of the physical machines is notified to the other physical machine which verifies the server apparatuses **231** and **232**.

FIG. **6** illustrates an exemplary message table.

A message table **124** is a table stored in the message storage unit **121**, the table having registered therein information about messages transmitted or received by the active server apparatuses **221** and **222**. The message table **124** includes columns of message number, time, transmission source address, destination address, method or code, path, and a plurality of parameters. For the messages transmitted or received by the verification server apparatuses **231** and **232**, a table of a structure similar to that of the message table **124** is stored in the verification message storage unit **123**.

A message number is an identifier for identifying a message. Message numbers are provided by the capture unit **131** in chronological order of transmission timing, for example. The time column has an entry of the point of time when a packet including a message is captured in the verification apparatus **100**. The transmission source address column has an entry of an identifier of a message transmission source, such as the transmission source IP address of the packet including the message. The destination address column has an entry of an identifier of a destination of a message such as the destination IP address of the packet including the message.

A method indicates the type of a request message, such as GET or POST specified in the header of an HTTP request. The POST method is mainly used when transmitting data which has been input to a form by a user, whereas the GET method is used when there is no such input data. A code indicates the type of a response message such as the HTTP status code. It is possible to check whether or not a request message has been normally processed by the server apparatuses **221** and **222** by referring to a code included in the response message.

The path column has an entry of an identifier of a Web resource (e.g., Web page) requested by the server apparatuses **221** and **222** such as the URL described in the header of the HTTP request. Each of the parameter columns has an entry of a pair of parameter name and value included in a message. There may exist a message including no parameter, a message including only one parameter, or a message including two or more parameters.

FIG. **7** illustrates an exemplary parameter detection table.

A parameter detection table **125** is generated while the parameter analysis unit **132** performs static analysis of a parameter, and is stored in the parameter information storage unit **122**. The parameter detection table **125** includes columns of client address, parameter name, and value thereof.

A client address is the address (e.g., IP address) of a client apparatus which transmitted a request message or a client apparatus to be the destination of a response message. The client address corresponds to the transmission source address of the message table **124** for a request message, and corresponds to the destination address of the message table **124** for a response message. The parameter name column has an entry of an identifier of a parameter described in a message. The value column has an entry of the value of a parameter described in a message.

FIG. **8** illustrates an exemplary analysis result table.

An analysis result table **126** is stored in the parameter information storage unit **122**. The analysis result table **126** includes columns of determination result, parameter name, and rewriting method.

The determination result column has "dependent" or "independent" described therein. "Dependent" indicates that a parameter is a status-dependent parameter whose value needs to be rewritten when verifying the server apparatuses **231** and **232**. "Independent" indicates that a parameter is a status-independent parameter whose value needs not to be rewritten when verifying the server apparatuses **231** and **232**.

The parameter name is similar to that entered in the parameter detection table **125**. The rewriting method column has described therein a method of obtaining the value of a status-dependent parameter at the time of verification. There is no rewriting method described for a status-independent parameter. As a rewriting method, there is conceivable, for example, a method which searches for a particular tag from among response messages received from the server apparatuses **231** and **232** immediately before a request message including a status-dependent parameter and uses the value described in the tag as the value of the status-dependent parameter. Accordingly, an appropriate value according to the context of communication between the verification apparatus **100** and the server apparatuses **231** and **232** is set to the status-dependent parameter.

Not all the parameters appearing in the message table **124** are entered in the analysis result table **126**. The parameter analysis unit **132** does not enter, in the analysis result table **126**, a parameter which is unidentifiable to be either a status-dependent parameter or a status-independent parameter by static analysis. In such a case, the communication reproduction unit **141** handles a parameter which has not been identified as either a status-dependent parameter or a status-independent parameter, initially as a status-independent parameter. However, a part or all of such a parameter may be estimated to be a status-dependent parameter by dynamic analysis performed by the parameter analysis unit **143**.

Next, procedure steps of the learning unit **130** and the verification unit **140** will be described.

FIG. **9** is a flow chart illustrating an exemplary procedure of parameter static analysis.

(S**10**) The parameter analysis unit **132** selects a message from the message table **124**. As a general rule, messages are selected in ascending order of message numbers.

(S**11**) The parameter analysis unit **132** determines whether or not at least one parameter is included in the selected message. When at least one parameter is included in the message, the processing of the following steps S**12** to S**18** are performed for each parameter. When no parameter is included, the process flow proceeds to step S**19**.

(S**12**) The parameter analysis unit **132** determines whether or not a pair of the client address (target client address) of the selected message and the parameter name of the parameter included in the message (target parameter name) has already been entered in the parameter detection table **125**. The process flow proceeds to step S**14** when the pair has already been entered in the parameter detection table **125**, or otherwise proceeds to step S**13**.

(S**13**) The parameter analysis unit **132** enters, in the parameter detection table **125**, the target client address, the target parameter name, and the value of a parameter set in the selected message (target parameter value) in association with each other.

(S**14**) The parameter analysis unit **132** searches the parameter detection table **125** for an entry in which the pair of the client address and the parameter name matches the pair of the target client address and the target parameter name, with the value being different from the target parameter value. The process flow proceeds to step S**15** when there exists a candidate entry, or otherwise proceeds to step S**17**.

(S**15**) The parameter analysis unit **132** determines the parameter indicated by the target parameter name to be a status-dependent parameter, and enters it in the analysis result table **126** in association with the determination result.

(S**16**) The parameter analysis unit **132** detects, from a response message immediately before the selected messages, a statement (e.g., an HTML tag) which specifies the target parameter name and sets the value thereof. The parameter analysis unit **132** then identifies a location where the value is set in the detected statement, and enters, in the analysis result table **126**, the method of extracting the value from the location as the rewriting method. Subsequently, the process flow proceeds to step S**19**.

(S**17**) The parameter analysis unit **132** searches the parameter detection table **125** for an entry in which a pair of the parameter name and value matches the pair of the target parameter name and the target parameter value, with the client address being different from the target client address. The process flow proceeds to step S**18** when there exists a candidate entry, or otherwise proceeds to step S**19**.

(S**18**) The parameter analysis unit **132** determines the parameter indicated by the target parameter name to be a status-independent parameter, and enters it in the analysis result table **126** in association with the determination result.

(S**19**) The parameter analysis unit **132** determines whether or not there remains an unselected message in the message table **124**. When there exists an unselected message, the process flow proceeds to step S**10** to process the next message (e.g., the message having the number incremented by one). When all the messages have been selected, static analysis of the parameter is completed.

As thus described, the parameter analysis unit **132** determines that a parameter having different values set in different messages transmitted or received by the same client apparatus is a status-dependent parameter. This is because when the same client apparatus sets different values for the same parameter, there is a high possibility that the parameter depends on the communication status of a session or the like. In addition, the parameter analysis unit **132** determines that a parameter having the same value set in different messages transmitted or received by different client apparatuses is a status-independent parameter. This is because when the different client apparatuses set the same value for a same parameter, there is a high possibility that the parameter does not depend on the communication status of a session or the like.

When determining a status-dependent parameter or a status-independent parameter, however, the parameter analysis unit **132** may request, in addition to equality of parameter name, equality of method or code, or equality of path. Accordingly, even when the same parameter name may be used for parameters having different meanings among Web pages of different paths, for example, it becomes possible to explicitly distinguish between such parameters having different meanings. In such a case, it suffices to add a column of method or code and a column of path to the parameter detection table **125**.

FIG. **10** is a flow chart illustrating an exemplary procedure of server verification.

(S**20**) The communication reproduction unit **141** extracts, from the message storage unit **121**, a list of messages (messages transmitted between a client apparatus and a server apparatus) having the same transmission source addresses and destination addresses. In the list, a plurality of messages is arranged in chronological order of transmission timing (e.g., in ascending order of message numbers).

(S**21**) The communication reproduction unit **141** selects one of the verification server apparatuses. The communication reproduction unit **141** then selects request messages from the list, one by one, in chronological order of transmission timing, and transmits the messages to the verification server apparatus. The next request message is transmitted after a response message for the preceding request message has been received. The communication reproduction unit **141** stores, in the verification message storage unit **123**, the request message transmitted to the verification server apparatus and the response message (or, a part of information of each message) received from the verification server apparatus.

When transmitting a request message, the communication reproduction unit **141** determines whether or not a status-dependent parameter is included in the request message to be transmitted, referring to the analysis result table **126**. When a status-dependent parameter is included, the communication reproduction unit **141** rewrites the value of the status-dependent parameter according to the rewriting method entered in the analysis result table **126**, and transmits a request message after parameter rewriting to the verification server apparatus. For example, the communication reproduction unit **141** extracts the value of the status-dependent parameter from the response message received from the verification system server apparatus immediately before, and sets the value to the status-dependent parameter of the request message to be transmitted.

(S**22**) The response comparison unit **142** selects one of the response messages received from the verification server apparatus. The response messages are selected in chronological order of reception timing.

(S**23**) The response comparison unit **142** identifies, from the list of step S**20**, a response message of the active system corresponding to the selected response message of the verification system, and compares the response messages of the verification system and the active system. The response comparison unit **142** then determines whether or not the two response messages are equivalent. For example, the response comparison unit **142** determines the two response messages to be equivalent when the HTTP status codes are the same, and not equivalent when the HTTP status codes are different. The process flow proceeds to step S**24** when the two response messages are equivalent, or otherwise proceeds to step S**25**.

(S**24**) The response comparison unit **142** determines whether or not there remains a message unselected at step S**22** among the response messages received from the verification server apparatus. The process flow proceeds to step S**22** when there exists an unselected message, or server verification is completed when all the messages have been selected. In the latter case, for example, the display control unit **150** causes the display **111** to display the verification result that the operation of the verification server apparatus is equivalent to that of the active server apparatuses **221** and **222**.

(S**25**) The parameter analysis unit **143** detects, from the verification message storage unit **123**, a request message transmitted to the verification server apparatus immediately before receiving the response message selected at step S**22**. The parameter analysis unit **143** then checks the parameter included in the detected request message. This request message may include no parameter, or may include two or more parameters.

(S**26**) The parameter analysis unit **143** determines whether or not there exists, in the set of parameters checked at step S**25**, a parameter which has not been identified to be either status-dependent or status-independent (a parameter which has not been entered in the analysis result table **126**). The process flow proceeds to step S**27** when there exists an undetermined parameter, or otherwise proceeds to step S**29**.

(S**27**) The parameter analysis unit **143** estimates the undetermined parameter to be a status-dependent parameter, and enters it in the analysis result table **126** in association with the determination result. When there are two or more undetermined parameters, the parameter analysis unit **143** may estimate all the undetermined parameters to be status-dependent parameters, or may estimate only an arbitrary one to be a status-dependent parameter.

(S**28**) The parameter analysis unit **143** searches for a response message received from the verification server apparatus immediately before the request message detected at step S**25**. The parameter analysis unit **143** then detects, from the detected response message, a statement which sets the value of the parameter estimated as a status-dependent parameter, determines the method of rewriting the value, and enters the method in the analysis result table **126**. Subsequently, the process flow proceeds to step S**21**, where the communication reproduction unit **141** communicates with the verification server apparatus again, based on the updated analysis result table **126**.

(S**29**) The display control unit **150** causes the display **111** to display a verification result (error) that the operation of the verification server apparatus is different from that of the active server apparatuses **221** and **222**.

Comparison (S**23**) of the response messages of the verification system and the active system may be started after communication (S**21**) between the verification apparatus **100** and the verification server apparatus is completed, or may be started before completion thereof. In the latter case, when it is determined that the response message of a verification system is not equivalent to that of the active system, communication between the verification apparatus **100** and the verification server apparatus may be terminated on that time point.

FIG. **11** illustrates an exemplary verification message.

Here, it is assumed that messages #1 to #6 have been transmitted between the client apparatus **211** and the server apparatus **221**. The message #1 is a request message. The message #2 is a response message with the code being 200 (normal). The message #3 is a request message and includes para1=aaa. The message #4 is a response message with the code being 200 and includes para2=bbb. The message #5 is a request message and includes para1=aaa and para2=bbb. The message #6 is a response message with the code being 200. In addition, it is assumed that para1 is determined to be a status-independent parameter by static analysis of the parameter analysis unit **132**, and para2 is undetermined.

When verifying the server apparatus **231** using the messages #1 to #6, the communication reproduction unit **141** transmits a request message to the server apparatus **231** without converting the value of the parameter at the first time. For example, the communication reproduction unit **141** transmits the message #1 to the server apparatus **231** and receives the message #2 with the code being 200. In addition, the communication reproduction unit **141** transmits the message #3 including para1=aaa to the server apparatus **231**, and receives the message #4a including para2=ccc with the code being 200. In addition, the communication reproduction unit **141** transmits the message #5 including para1=aaa and para2=bbb to the server apparatus **231**, and receives the message #6a with the code being 500 (error).

The response messages to the message #1 have the same code in the active system and the verification system and therefore the response messages may be estimated to be equivalent. The response messages to the message #3 also have the same code in the active system and the verification system and therefore the response messages may be estimated to be equivalent. On the other hand, the response messages to the message #5 have different codes between the active system and the verification system and therefore the response messages may not be estimated to be equivalent (normal and error).

Therefore, the parameter analysis unit **143** extracts para2, which has not been determined yet, from the message #5 transmitted to the server apparatus **231** immediately before the message #6a which turned out to be an error, and estimates para2 to be a status-dependent parameter. In addition, the parameter analysis unit **143** determines the method of rewriting the value of the status-dependent parameter from the message #4a received from the server apparatus **231** immediately before the message #5. Here, the parameter analysis unit **143** determines that the value of para2 included in the message #4a needs to have been used in the message #5.

The communication reproduction unit **141** then transmits a request message to the server apparatus **231** while converting the value of para2 at the second time. For example, the communication reproduction unit **141** transmits the message #1 to the server apparatus **231** and receives the message #2 with the code being 200. In addition, the communication reproduction unit **141** transmits the message #3 including para1=aaa to the server apparatus **231** and receives the message #4b including para2=ddd with the code being 200. In addition, the communication reproduction unit **141** transmits the message #5b including para1=aaa and para2=ddd to the server apparatus **231**, and receives the message #6a with the code being 200.

The messages #2, #4b, and #6 which are response messages of the verification system at the second time have the same codes as those of the messages #2, #4 and #6 of the active system, and therefore may be estimated to be equivalent. As thus described, para2 which has not been determined by static analysis of the parameter analysis unit **132** is estimated to be a status-dependent parameter by dynamic analysis of the parameter analysis unit **143**. Accordingly, the mismatch of response messages due to inappropriately rewritten value of a session-dependent or a server-apparatus-dependent parameter may be removed in the course of communication with the verification server apparatus.

Next, a variation of static analysis performed by the parameter analysis unit **132** will be described. In the foregoing description, comparison of parameter names and values thereof between messages has been preferentially performed in ascending order of message numbers. In the variation described below, comparison is performed in a preference order different from the foregoing.

FIG. **12** illustrates a first example of the message selection method.

The parameter analysis unit **132** may select, from among the messages entered in the message table **124**, a request message more preferentially than a response message, and extract a set of client address, parameter name and value. In addition, the parameter analysis unit **132** may extract a set of client address, parameter name and value only from a request message.

For example, the parameter analysis unit **132** extracts "version=1.0" from the request message having "number=1" and enters it in the parameter detection table **125**. Next, skipping the response message having "number=2", the parameter analysis unit **132** extracts "authtoken=0fa5" and "user=Taro" from the request message having "number=3", and enters them in the parameter detection table **125**. Next, the parameter analysis unit **132** skips the response message having "number=4" and extracts "version=1.0" from the request message having "number=5". Since the client address, and the parameter name and value are the same as existing ones, the parameter analysis unit **132** does not determine "version" to be either a status-dependent parameter or a status-independent parameter at this point.

Next, the parameter analysis unit **132** skips the response message having "number=6" and extracts "authtoken=3b2c" and "user=Taro" from the request message having "number=7". Although the client address and the parameter name for "auth_token" are the same as existing ones, the value thereof is different from the existing one. Therefore, the parameter analysis unit **132** determines "auth_token" to be a status-dependent parameter. The parameter analysis unit **132** does not determine "user" to be either a status-dependent parameter or a status-independent parameter at this point.

Next, the parameter analysis unit **132** skips the response message having "number=8" and extracts "version=1.0" from the request message having "number=9". Since the parameter name and value are the same as existing ones whereas the client address is different from the existing one, the parameter analysis unit **132** determines "version" to be a status-independent parameter. Next, the parameter analysis unit **132** skips the response message having "number=10" and extracts "authtoken=d97e" and "user=Jiro" from the request message having "number=11". The parameter analysis unit **132** does not determine "user" to be either a status-dependent parameter or a status-independent parameter.

As thus described, skipping response messages may reduce the number of messages to be processed. In addition, since the number of parameters included in a request message is usually smaller than the number of parameters included in a corresponding response message, the number of comparisons between parameters may be reduced. On the other hand, in terms of detecting a parameter whose value is to be rewritten when transmitting a request message to the server apparatuses **231** and **232**, a parameter included in the request message are more important than a parameter included in the response message. Therefore, static analysis of parameters may be performed efficiently by selecting a request message preferentially.

After having processed a request message preferentially, the parameter analysis unit **132** may further process a response message. In this occasion, the parameter analysis unit **132** may allow a user to choose whether or not to continue the static analysis when having processed the request message, and may further process the response message when the user chooses to continue the static analysis. In addition, the parameter analysis unit **132** may process response messages in succession while the elapsed time from starting the static analysis to completing processing of request messages is equal to or less than a threshold value. Alternatively, the parameter analysis unit **132** may keep selecting messages until the elapsed time from starting the static analysis reaches a threshold value. Accordingly, the determination precision of a status-dependent parameter may be improved in a range where the processing time is not too long.

Next, another method of selecting messages will be further described.

FIG. **13** is a flow chart illustrating another exemplary procedure of parameter static analysis.

(S**30**) The parameter analysis unit **132** divides the set of messages entered in the message table **124** into a plurality of blocks, maintaining the time sequence. For example, the parameter analysis unit **132**, having preliminarily determined the number of messages per block (predetermined number), groups the messages by the predetermined number in chronological order of transmission timing.

(S**31**) The parameter analysis unit **132** initializes the block number N to 1.

(S**32**) The parameter analysis unit **132** selects, from the block column maintaining the time sequence, the Nth block from the top (Nth oldest transmission timing).

(S**33**) The parameter analysis unit **132** performs parameter static analysis illustrated in FIG. **9** in the block selected at step S**32**. For example, the parameter analysis unit **132** selects a message in the selected block in chronological order of transmission timing, and enters the extracted client address, parameter name and value in the parameter detection table **125**.

(S**34**) The parameter analysis unit **132** determines whether or not there remains a block which has not yet been selected at step S**32** or step S**35** described below. The process flow proceeds to step S**35** when there exists an unselected block, or otherwise the parameter static analysis is completed.

(S**35**) The parameter analysis unit **132** selects, from the block column maintaining the time sequence, the Nth block from the bottom (Nth newest transmission timing).

(S**36**) The parameter analysis unit **132** performs the parameter static analysis illustrated in FIG. **9** in the block selected at step S**35**. For example, the parameter analysis unit **132** selects a message in the selected block in chronological order of transmission timing, and enters the extracted client address, parameter name and value in the parameter detection table **125**.

(S**37**) The parameter analysis unit **132** determines whether or not there remains a block which has not yet been selected at step S**32** or step S**35**. The process flow proceeds to step S**38** when there exists an unselected block, or otherwise the parameter static analysis is completed.

(S**38**) The parameter analysis unit **132** increments the block number N (adds one to the value), and the process flow proceeds to step S**32**. The parameter detection table **125** keeps being used without initialization while parameter analysis of steps S**33** and S**36** is being repeated. In other words, the set of client address, parameter name and value extracted in a block is to be compared with a set extracted in another block.

FIG. **14** illustrates a second example of the message selection method.

Here, 10,000 messages have been entered in the message table **124** and divided into 2000 blocks each including five messages. First, the parameter analysis unit **132** processes messages #1 to #5 belonging to the first block from the top. Next, the parameter analysis unit **132** processes messages #9996 to #10000 belonging to the first block from the bottom. Next, the parameter analysis unit **132** processes messages #6 to #10 belonging to the second block from the top. Next, the parameter analysis unit **132** processes messages #9991 to #9995 belonging to the second block from the bottom.

As thus described, the parameter analysis unit **132** may perform a comparison of parameters between temporally-separated messages more preferentially than a comparison of parameters between temporally-close messages. Here, values of session-dependent parameters are the same, as a general rule, between messages belonging to the same session. In addition, there is a high possibility that messages transmitted by the same client apparatus at close transmission timings belong to the same session. Therefore, the parameter analysis unit **132** may perform a comparison of parameters between messages belonging to different sessions at an early stage by selecting messages in the order described above, allowing efficient detection of session-dependent parameters.

According to the information processing system of the second embodiment, it is possible to automatically determine, from among parameters which may be included in a message, status-dependent parameters such as session-dependent parameters or server-apparatus-dependent parameters. Therefore, when verifying the verification server apparatuses **231** and **232**, using messages transmitted between the client apparatuses **211** and **212** and the active server apparatuses **221** and **222**, it becomes possible to prevent incorrect verification due to deficiency of parameter values. In addition, the user need not preliminarily define the status-dependent parameter whose value is to be rewritten and therefore the user need not know the details of the software to be executed on the server apparatuses **221**, **222**, **231** and **232**, and thereby the burden of the user is reduced.

## Third Embodiment

A third embodiment will be described. Difference from the aforementioned second embodiment will be mainly described, and description of items similar to those of the second embodiment will be omitted.

In the second embodiment, the verification apparatus **100**, the client apparatuses **211** and **212**, and the server apparatuses **221**, **222**, **231** and **232** are separate physical machines respectively connected to a network. However, it is also possible to virtualize two or more of the aforementioned computers and cause the two or more virtual machines to operate on the same physical machine. In the third embodiment, an example will be described in which virtual machines corresponding to the verification apparatus **100**, the server apparatus **221** (active system), and the server apparatus **231** (verification system) operate on the same physical machine.

FIG. **15** is a block diagram illustrating another exemplary function of the server apparatuses.

A server apparatus **300** has virtual machines **310**, **320** and **330**, and a hypervisor **340**. The virtual machines **310**, **320** and **330**, and the hypervisor **340** operate using a CPU and a RAM, for example. The virtual machine **310** corresponds to the server apparatus **221** of the second embodiment, and the virtual machine **320** corresponds to the server apparatus **231** of the second embodiment. The virtual machine **330** corresponds to the verification apparatus **100** of the second embodiment.

The virtual machine **310** executes the OS and server software **311** thereon. The server software **311** may be the same as the one being executed on the server apparatus **221**. The virtual machine **320** executes the OS and server software **321** thereon. The server software **321** may be the same as the one being executed on the server apparatus **231**. The virtual machine **330** executes the OS and verification software **331** thereon. The verification software **331** includes, for example, a module corresponding to the learning unit **130** and the verification unit **140**.

The hypervisor **340** provides control so that a plurality of virtual machines operates in parallel. The hypervisor **340** allocates, to the virtual machines **310**, **320** and **330**, resources provided in the server apparatus **300** such as the number of CPU clocks or RAM areas. The OS operating on each virtual machine provides control so that the application software is executed on the virtual machine within the resources allocated by the hypervisor **340**.

The hypervisor **340** has a virtual switch **341**. The virtual switch **341** manages band resources of the communication interface provided in the server apparatus **300**. In addition, the virtual switch **341** relays messages between the virtual machines **310**, **320** and **330**, and between a communication apparatus outside the server apparatus **300** and the virtual machines **310**, **320** and **330**. For example, the virtual switch **341** relays messages between the client apparatuses **211** and **212** and the virtual machine **310**, and outputs copies of the messages to the virtual machine **330**. In addition, the virtual switch **341** relays messages between the virtual machine **320** and the virtual machine **330**.

According to the information processing system of the third embodiment, an effect similar to that of the second embodiment is brought about. Furthermore, in the third embodiment, it is possible to consolidate, using the computer virtualization technology, a plurality of computers having different functions on the same physical machine, thereby suppressing the management cost of the information processing system. In addition, collection of messages transmitted or received by the server software, or verification of the server software may be efficiently performed using a virtual machine.

As has been described above, information processing of the first embodiment may be realized by causing the information processing apparatus **10** to execute a program. In addition, the information processing of the second embodiment may be realized by causing the verification apparatus **100** to execute a program, and the information processing of the third embodiment may be realized by causing the server apparatus **300** to execute a program.

A program may be stored in a computer-readable recording medium (e.g., the recording medium **113**). As a recording medium, a magnetic disk, an optical disk, an MO (Magneto-Optical) disk, a semiconductor memory or the like may be used, for example. The magnetic disk includes a floppy disk or an HDD. The optical disk includes a CD (compact disk), a CD-R (Recordable)/RW (Rewritable), a DVD or DVD-R/RW. A program may be stored in a portable recording medium for distribution. In such a case, the program may be copied (installed) on another recording medium such as an HDD (e.g., the HDD **103**) from the portable recording medium for execution.

In one aspect, it becomes easy to verify a server, using a message related to another server.

All examples and conditional language provided herein are intended for the pedagogical purposes of aiding the reader in understanding the invention and the concepts contributed by the inventor to further the art, and are not to be construed as limitations to such specifically recited examples and conditions, nor does the organization of such examples in the specification relate to a showing of the superiority and inferiority of the invention. Although one or more embodiments of the present invention have been described in detail, it should be understood that various changes, substitutions, and alterations could be made hereto without departing from the spirit and scope of the invention.

What is claimed is:

**1**. An information processing apparatus comprising:

a memory configured to store a plurality of messages transmitted from a client to a server, the plurality of messages including a first message and a second message, the first message including a name of a parameter and a first value of the parameter, the second message including the name of the parameter and a second value of the parameter; and

a processor configured to perform a procedure including:

comparing the first value and the second value and, according to a result of the comparing, determining whether the parameter is a status-dependent parameter whose value depends on a communication status between the client and the server; and

when the parameter is a status-dependent parameter, rewriting the first value of the first message and the second value of the second message, and transmitting the rewritten first message and the rewritten second message to another server for verification of said another server.

**2**. The information processing apparatus according to claim **1**, wherein

the plurality of messages further includes a third message, the third message including the name of the parameter and a third value of the parameter;

transmission of the third message from the client to the server is later than the first message and earlier than the second message; and

the comparing between the first value and the second value is performed prior to a comparison between the first value and the third value.

**3**. The information processing apparatus according to claim **1**, wherein when the first value and the second value are different, the parameter is determined as a status-dependent parameter.

**4**. The information processing apparatus according to claim **1**, wherein

the memory further stores a fourth message transmitted from another client to the server, the fourth message including the name of the parameter and a fourth value of the parameter, and

the procedure further includes:

comparing the first value and the fourth value and, when the first value and the fourth value are same, determining the parameter as a status-independent parameter whose value is independent from the communication status; and

when the parameter is a status-independent parameter, transmitting the first message and the second message to said another server without rewriting the first value and the second value.

**5**. The information processing apparatus according to claim **1**, wherein

the memory further stores a response message transmitted from the server to the client, the response message including the name of the parameter and a fifth value of the parameter, and

the comparing between the first value and the second value is performed prior to a comparison between the first value and the fifth value.

**6**. The information processing apparatus according to claim **5**, wherein

transmission of the response message from the server to the client is earlier than the second message; and

the procedure further includes determining a method of rewriting the second value of the second message, based on the response message.

**7**. A verification control method comprising:

obtaining, by a processor, a plurality of messages transmitted from a client to a server, the plurality of messages including a first message and a second message, the first message including a name of a parameter and a first value of the parameter, the second message including the name of the parameter and a second value of the parameter;

comparing, by the processor, the first value and the second value and, according to a result of the comparing, determining whether the parameter is a status-dependent parameter whose value depends on a communication status between the client and the server; and

when the parameter is a status-dependent parameter, rewriting, by the processor, the first value of the first message and the second value of the second message, and transmitting the rewritten first message and the rewritten second message to another server for verification of said another server.

**8**. A non-transitory computer-readable recording medium storing a computer program, wherein the computer program, when executed by a computer, causes the computer to perform a procedure comprising:

obtaining a plurality of messages transmitted from a client to a server, the plurality of messages including a first message and a second message, the first message including a name of a parameter and a first value of the parameter, the second message including the name of the parameter and a second value of the parameter;

comparing the first value and the second value and, according to a result of the comparing, determining whether the parameter is a status-dependent parameter whose value depends on a communication status between the client and the server; and

when the parameter is a status-dependent parameter, rewriting the first value of the first message and the second value of the second message, and transmitting the rewritten first message and the rewritten second message to another server for verification of said another server.

* * * * *